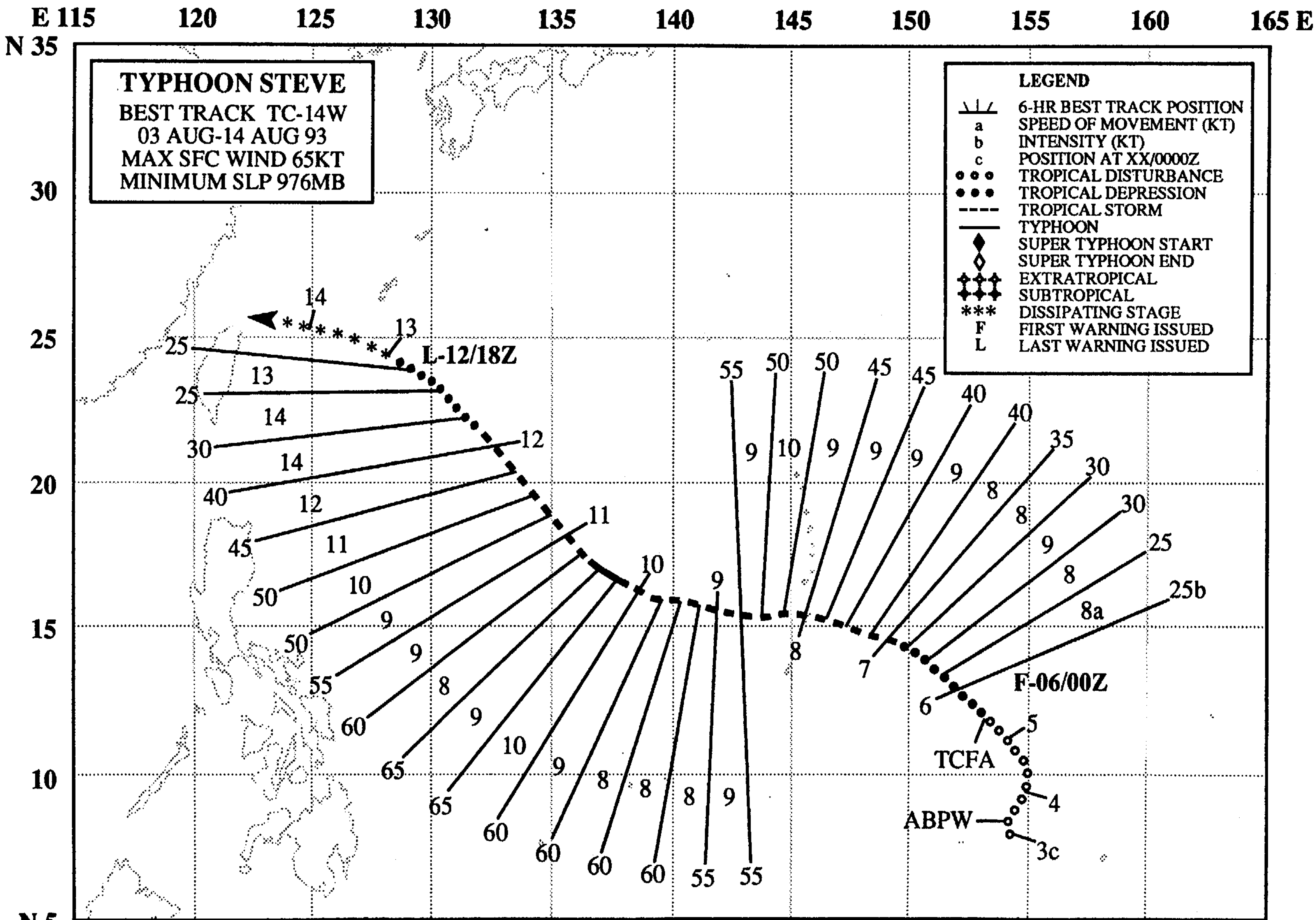
TYPHOON STEVE
BEST TRACK TC-14W
03 AUG-14 AUG 93
MAX SFC WIND 65KT
MINIMUM SLP 976MB
LEGEND
6-HR BEST TRACK POSITION
a SPEED OF MOVEMENT (KT)
b INTENSITY (KT)
c POSITION AT XX/0000Z
TROPICAL DISTURBANCE
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON
SUPER TYPHOON START
SUPER TYPHOON END
EXTRATROPICAL
SUBTROPICAL
*** DISSIPATING STAGE
F FIRST WARNING ISSUED
L LAST WARNING ISSUED
E 115
120
125
130
135
140
145
150
155
160
165 E
N 35
30
25
20
15
10
N 5
L-12/18Z
F-06/00Z
TCFA
ABPW
3c
25b
8a

TYPHOON STEVE (14W)

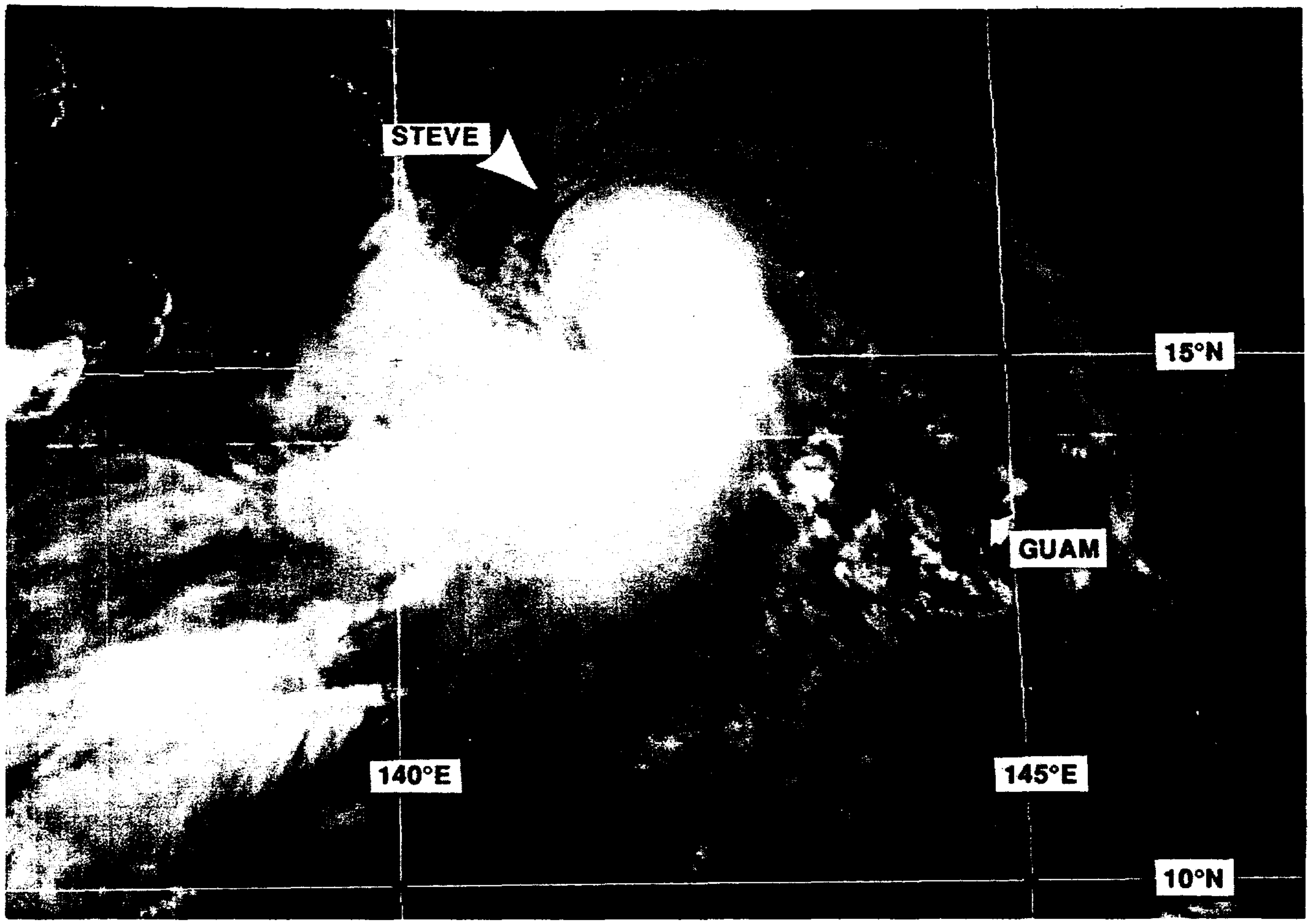

Figure 3-14-1 To the northwest of Guam, Steve continues to slowly intensify (082331Z August visual GMS imagery).

I. HIGHLIGHTS

Forming in the wake of, Robyn (13W), Steve became the second tropical cyclone of August. Despite the appearance of strong upper-level westerly wind shear from Robyn's outflow, Steve was able to attain minimal typhoon intensity. Later, however, the typhoon was subjected to strong easterly shear and rapidly dissipated over the open ocean south of Okinawa.

I. CHRONOLOGY OF EVENTS

August

030600Z - The tropical disturbance was first mentioned on the Significant Tropical Weather advisory as an area of persistent convection enhanced by a surge in the southwest monsoon.

051300Z - The appearance of a developing cyclonic circulation on the animated cloud imagery prompted the issuance of a Tropical Cyclone Formation Alert.

060000Z - The first warning was issued based on the improved organization of the convection as viewed on the the first visual satellite image of the day.

070000Z - Steve was upgraded to tropical storm intensity based on improved convective organization and the resulting 35-kt (13-m/sec) satellite intensity estimate.

080835Z - Warning responsibility transferred to the Alternate Joint Typhoon Warning Center at Pearl Harbor, Hawaii after an 8.1 magnitude earthquake near Guam temporarily knocked out power and communications.
081800Z - Warning responsibility returns to JTWC.
100600Z - Steve was upgraded to typhoon intensity based on the appearance of a cloud-filled eye.
121800Z - The final warning was issued on Steve following rapid dissipation over water in an environment featuring strong upper-level easterly winds.

III. IMPACT

Tropical Storm Steve caused Saipan and Tinian to go to Condition of Readiness (COR) 1. Saipan recorded sustained winds of 45 kt (23 m/sec) with gusts to 60 kt (31 m/sec) and experienced extensive flooding on the island due to heavy rains on 8 August. The large PACOM combined exercise, TANDEM THRUST, was prematurely ended when troops prepositioned on the island of Tinian were evacuated and a planned amphibious assault of the island was canceled due Steve's approach.

IV. DISCUSSION

As Steve developed and moved westward, it came under the upper-level outflow of Typhoon Robyn (13W). Despite the appearance of strong upper-level wind shear, Steve managed to continue to slowly intensify. As Robyn moved northwestward toward the Ryukyu Islands, the upper-level shear appeared to weaken as Steve slowly intensified (Figure 3-14-1). On the afternoon of 10 August, Steve was upgraded to typhoon intensity and coincidently made a track change from westward to northwestward. After reaching minimal typhoon intensity, Steve began to weaken apparently in association with the establishment of northeasterly flow aloft. This flow became established as Robyn recurved into midlatitudes and a large upper-level anticyclone formed east of Japan.

It is interesting to note that Steve intensified slowly in an environment that featured upper-level westerly winds, but weakened rapidly in an environment that featured upper-level northeasterly winds. A closer look at these two upper-level wind regimes follows.

a. Intensification despite westerly wind shear — Steve comes under the influence of the outflow from Typhoon Robyn. The fact that Steve is able to maintain a central dense overcast (CDO), suggests that the system's own outflow is able to hold its own against that of Robyn's, thus deflecting the westerly winds and preventing the shear from reaching the central core. It is suggested that in order for Steve to survive, its outflow has to maintain a buffer sufficient to keep the westerly winds from disrupting the vertical structure of the core of the storm. The deflection of the westerly upper-level winds around Steve's cloud system may not be as difficult as it would appear at first glance. The wind at 200 mb near Robyn was strongly cyclonic for a radius of several hundred miles. Thus, the upper-level westerly winds (as indicated by the orientation of the cirrus cloud plumes) in the vicinity of Steve — located downstream from Robyn's outflow to the east — were probably relatively high and relatively shallow. The thinness of the ambient cirrus is further evidence that the upper-level westerly flow over Steve was relatively high (at the 200-mb pressure height and higher) and shallow (confined between the 200-mb level upward to just above the tropopause). The relatively straight-line westerly winds from the high-level outflow streaming from Robyn and across the region of Steve lasted for three days (5-7 August) in the manner illustrated in the model in Figure 3-14-2a. There was a gradual shrinking of the convection in response to the shear during those three days (Figure 3-14-3a). By 8 August, the upper-level flow had become strongly diffluent in the region of Steve, flowing northward into a cell in the TUTT to the northwest of Steve, and turning anticyclonically into strong easterlies south of Steve. This diffluent pattern is illustrated in the synoptic model in Figure 3-14-2b. Steve was thus placed in an area of maximum anticyclonic curvature which not only reduced the shear above the storm, but also placed Steve in a region of upper-level divergence — two factors commonly believed to be favorable for intensification. While all the shear was probably not eradicated, it was sufficiently reduced for a long-enough period of time to allow Steve to survive, and to grow in size and intensity as illustrated by the size of the cirrus shield in Figure 3-14-3b.

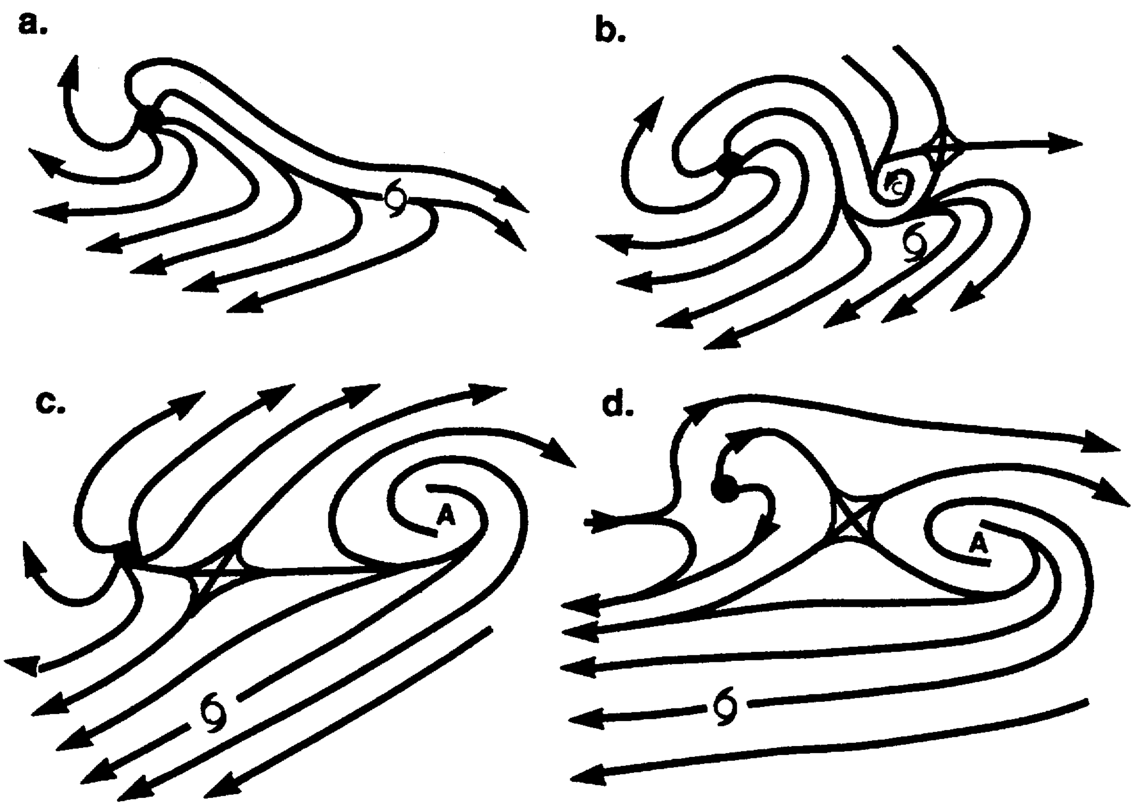

Figure 3-14-2 A model of upper-level streamlines based on composited 200-mb winds and cirrus plume orientations taken from satellite imagery associated with Robyn (13W) and Steve: (a) Composite for 5 through 7 August, (b) Composite for 8 through 10 August, (c) Composite for 10 and 11 August, and (d) Composite for 12 and 13 August. Solid black dot = the location of Robyn and tropical cyclone symbol = Steve.

b. Weakening with Strong Upper-Level Easterly Winds — In this case, the ambient flow is deep and non-diffluent easterly with speed increasing with height (Figure 3-14-2c and d). The easterly winds also act to block any outflow to the poleward side of the storm. The result is no intensification and eventual weakening. It is common to observe the decoupling of the convection and the low-level circulation, with the convection going in one direction and the exposed low-level circulation center going in another, as was observed with Steve. While subjected to strong upper-level northeasterly wind (later veering to easterly), the size of Steve's cirrus shield rapidly shrank (Figure 3-14-3c). Steve could not maintain its vertical structure against easterly winds aloft.

c. Rules of Thumb — 1) Upper-level westerly or southwesterly winds from a tropical cyclone can create a downstream environment to the east that is favorable for the development or intensification of another tropical cyclone, despite the appearance (on satellite imagery) of strong westerly shear across the downstream tropical cyclone. The upper-level westerly winds are generally in a shallow layer, high, and strongly diffluent. Convection is favored at the location of the second (or downstream) tropical cyclone as a quasi-stationary trough amplifies in the upper-level flow between the two tropical cyclones. 2) In contrast, strong easterly or northeasterly upper-level winds across a tropical cyclone tend to shear away the convection leaving the low-level circulation center exposed.

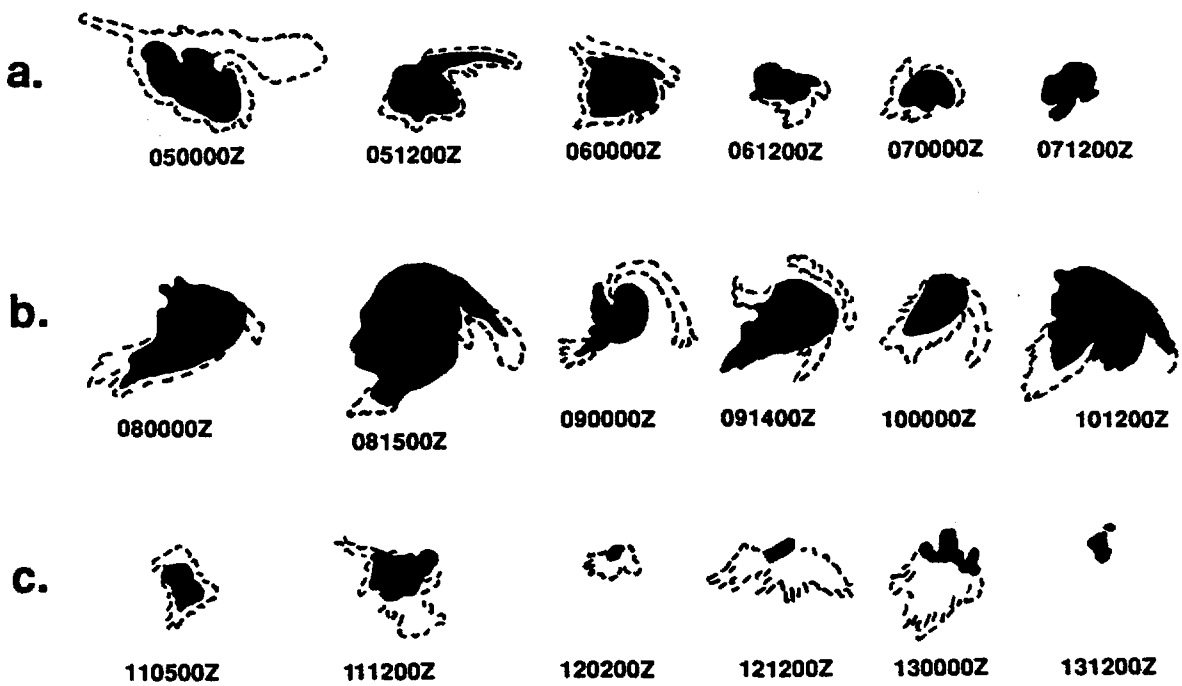

Figure 3-14-3 Illustration depicting the size and shape of Steve's cirrus canopy from 5 to 13 August: (a) unidirectional westerly winds aloft, (b) highly diffluent west winds aloft, and (c) unidirectional easterly winds aloft. Black areas = dense cirrus overcast and dashed lines = the extent of thin cirrus.